DOCUMENT RESUME

ED 252 393 SE 045 312

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TITLE Confronting the Problems of Primary School Science. Learning in Science Project (Primary). Working Paper No. 110.
INSTITUTION Waikato Univ., Hamilton (New Zealand). Science Education Research Unit.
PUB DATE Dec 82
NOTE 17p.; For related document, see SE 045 303.
PUB TYPE Reports - Evaluative/Feasibility (142)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Concept Formation; *Curriculum Development; *Educational Objectives; Elementary Education; *Elementary School Science; Foreign Countries; Learning Strategies; *Research Needs; Science Curriculum; Science Education; *Science Instruction; Science Projects
IDENTIFIERS *Learning in Science Project (Primary); *New Zealand; Science Education Research

ABSTRACT

The Learning in Science Project (Primary)--LISP(P)--was designed to investigate the teaching and learning of science in the primary school. This paper summarizes the work undertaken and the findings obtained during the first 9 months of the project. During the first 6 months, an exploratory phase, similar to the original Learning in Science Project (LISP), was undertaken. Based on interviews with educational personnel and students and on observations of classroom interactions, difficulties in teaching science related to teacher background, organization, and the aims of science education were found. In addition, it was found that children have strong views about topics prior to learning, that these views are often different from scientists' views, and that these views can remain uninfluenced (or be influenced in unanticipated ways) by science teaching. A perspective on primary school science is offered with implications related to science topics and concepts, doing things, skills of investigations, student explanations, teaching strategies, and classroom implementation. The paper concludes with summaries of six LISP(P) studies. Areas investigated include: topics children are most interested in; questions children ask in a given situation; questions of greatest interest to children; and explanations or answers to questions generated by children. (JN)

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LEARNING IN SCIENCE PROJECT (PRIMARY)

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CONFRONTING THE PROBLEMS OF PRIMARY SCHOOL SCIENCE

Science Education Research Unit
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Hamilton, N.Z.

SE 045 312

Working Paper No. 110

CONFRONTING THE PROBLEMS OF PRIMARY SCHOOL SCIENCE

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December 1982

A Working Paper of the Learning in Science Project (Primary)

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BACKGROUND

From February 1979 until January 1982 a government funded research programme, the Learning in Science Project, was based at the University of Waikato. The Project investigated some of the difficulties of teaching and learning science at the Form 1-4 level and explored ways whereby some of the key difficulties might be overcome. Osborne and Freyberg (1982) describe the main findings of that Project and reference the 54 Working Papers, and many of the published papers, which resulted from the Project.

In February 1982 a new project, the Learning in Science Project (Primary) commenced at the University of Waikato. This is a similar three year study of the teaching and learning of science, but at the Standard 2-4 level. This paper summarises the work undertaken, and the findings obtained, during the first nine months of the Project.

EXPLORING THE DIFFICULTIES

In the first six months of the Project an exploratory phase, similar in nature to the exploratory phase of the original Learning in Science Project, was undertaken. Almost one hundred inspectors, teachers' college science staff, science advisers, principals, teachers and pupils were interviewed about, and commented on, their experience of the teaching and learning of science at the Standard 2-4 level. Using a grounded theory approach (Glaser and Strauss, 1967) the perceived difficulties were isolated and reported by Biddulph (1982a). In addition a range of lessons was observed and pupils and teachers were talked to in the classroom setting. Findings from this work were also reported by Biddulph (1982b).

Biddulph (1982a) found that a substantial number of the people interviewed thought that many teachers tend to avoid teaching science. Those interviewed considered that when science is taught it is frequently teacher dominated, children's ideas tend to be ignored, and a genuine spirit of inquiry is frequently not encouraged. Examples quoted include,

> "They (teachers) only ask questions when they know the answers exactly and if they do not get the answers they will keep nodding and looking until they get the answer they want and the words they want."
>
> (Primary inspector)

and

> "I tend to think that there are a lot of teachers who would stifle questions in a way to suit themselves rather than the children."
>
> (Primary principal)

The reported experiences of pupils reinforce the view that the difficulties outlined are important ones. While science is undoubtedly enjoyed by children when they experience new activities and learn new things, they do not enjoy what they perceive as too much teacher talk, too much writing, too much repetition of topics and situations in which they do not understand words and ideas (Biddulph, 1982a).

Observations of lessons reinforced many of the interview statements (Biddulph, 1982b). Particular difficulties with activity based work were observed; the problem to be investigated, the procedure for solving the problem and often the conclusion to be drawn from the experience tended all to be teacher dominated. As Tasker (1981) found at the Form 1-4 level, the teacher's problem often does not become the pupils' problem, the procedure suggested for solving the problem is not fully appreciated, and little notice is often taken of the pupils' own conclusions. Pupils often do things, learn things and have problems of which teachers' are unaware; they translate instructions into unanticipated actions, they often play games with the teacher to find the right answer that the teacher requires, and they copy the teacher's conclusions from blackboard to book with no real appreciation of how those words relate to what they found out themselves. As one pupil stated, "You just do it to please the teacher".

The findings of all this work tended to confirm that many of the difficulties isolated in the Form 1-4 Learning in Science Project, and described in Tasker, Freyberg and Osborne (1982), also exist at the Standard 2-4 level. The work undertaken in both Projects, in addition to other work undertaken in this country and overseas, suggests the main difficulties include:

i) Teacher Background: Teachers lack confidence in science teaching, mostly because they consider that they have a personal lack of science knowledge and experience in science inquiry. This is a major difficulty, certainly not unique to New Zealand, which needs to be overcome if the potential of teachers is to be harnessed in effective primary science teaching.

ii) Practical Difficulties: While many teachers appreciate the specific guidance provided by the available resource units, there remain practical and organisational difficulties which limit teachers' confidence and limit the amount of science that is taught. There are significant difficulties in storing, organising and setting out equipment and materials. There are difficulties in focussing pupil attention, of ensuring that pupils use the equipment in anticipated and desired ways, and in coping with the questions raised by children as they attempt to integrate new experiences into their way of thinking about the world.

iii) Aims of Science Education: Many primary teachers do not have a conviction that science is an essential and important area of the curriculum. Associated with this, there are divergent views about the aim of science in the primary school. While some argue that primary science should develop skills to solve problems in a "scientific way", the actions of many teachers in the classroom suggest that either science teaching is considered to involve getting across a body of scientific knowledge to children or that science teaching is simply a vehicle for vocabulary extension. Teachers may well adopt certain aims for science teaching as a way of rationalizing in their own minds why some of the practical difficulties associated with their own lack of knowledge or confidence need not be faced.

In addition to the above findings, other findings from the original Learning in Science Project also have a number of implications for Primary Science. In that project children's views of the world and meanings for words were explored at all age levels. The present research has confirmed that,

i) children have strongly held views about a variety of topics in science from a young age and prior to learning formal science,

ii) children's views are often different to scientists' views, they are frequently not well known, and to children they are sensible and useful views, and

iii) children's views can remain uninfluenced, or be influenced in unanticipated ways, by science teaching.

In this exploratory work we have concentrated on the difficulties of primary science teaching. We have not attempted to evaluate primary school science, nor to provide a balanced view of the good and bad aspects of this science teaching. The difficulties we have isolated are not unique to the primary level of education, to New Zealand, or even to science education. As Barnes (1976) comments from his studies across the curriculum in the U.K.

> "Pupils conform, and even play the system, but many do not allow the knowledge presented to them to make any deep impact upon their view of reality." (p.17)

A PERSPECTIVE ON PRIMARY SCIENCE

As we have already discussed, primary school teachers are not, in general, committed to the teaching of science. Rather their concern is for the general development of children across a wide curriculum. Science syllabuses and resources at the primary school level which do not take into account teachers' needs and concerns are likely to result in a reduction in the amount of science taught. Furthermore, research which simply points out mismatches between the teaching and learning of science is likely to have the same effect; teachers may simply reduce the science component of the curriculum actually provided in the classroom.

In addition there is a divergence of opinion about the relative importance of influencing children's concepts, process skills and attitudes at the primary school level not only amongst teachers but also amongst science educators both nationally and internationally.

To enable us to proceed tc overcome some of the difficulties isolated in the exploratory phase of the Project, we the researchers first needed to consider our own assumptions about children and about science. Our views have been influenced by many researchers (Piaget, 1966; Kelly, 1969; Wittrock, 1977) and our own empirical and theoretical work (Osborne and Freyberg, 1982; Osborne and Wittrock, 1982). Reflection on this work has led us to firmly support the view that learners construct meaning for themselves as they attempt to make sense of their interactions with objects and people. Construction of personal knowledge begins at birth and continues through life. Children do things, ask questions of themselves and others, and seek to make sense of their world. In so far as we help children to be able to do things in the physical, natural and technological worlds; to ask useful and productive questions about this world, and to make better sense in their own minds as to how and why things behave as they do, we are teaching science. Furthermore in our view this should be the prime aim of science teaching at the primary school level. Secondary to this, while we need to help younger children to act on, observe, and attempt to understand their immediate world in their own way as they grow, we also need to help them:

i) appreciate and be interested in a wider view of the world; and

ii) be interested in other people's explanations of the world and how such explanations have been obtained.

The above then, which is reported more fully in Symington, Osborne Freyberg and White (1982), is our position on science in the primary school. In addition, it is our view that any science programme must also take into account the desire of teachers to maintain feelings of professional competence. Primary science needs to be manageable by teachers in that teachers must feel that they have control over the teaching situation.

Primary science programmes should enable teachers to grow in confidence through helping them to better understand, predict and control events in their classroom. If the programmes for teaching science do not help the teacher in these ways science will not be taught in primary schools.

IMPLICATIONS

The above perspective on primary science has implications for the teaching and learning of science. Topics need to be chosen which are of interest to children; concepts need to be focussed on which will help children understand everyday phenomena, and which are within their grasp; children need time to explore and do things within particular situations; children need to be encouraged to ask questions and to form explanations; children need to be encouraged to consider alternative explanations and be ready to change their ideas; children need to be involved in carrying out investigations of questions, and of alternative explanations, which are relevant to them; children should be helped to develop those investigatory skills which will enable them to effectively obtain useful answers to their questions[1] and; children should begin to appreciate the kinds of questions, explanations and investigatory procedures of interest to scientists. These implications are explored further in Symington et.al. (1982).

There is nothing new in the above suggestions. The problem is to find a way whereby these ideals might be achieved in practice. To be successful we must find a way for teachers to gain confidence and greater control of their world at the same time as children achieve more meaningful

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[1] Such skills should not be limited to hands-on enquiry skills. Children need to develop the ability to obtain information from reference material and knowledgeable individuals.

interaction with their physical, natural and technological worlds. This is no simple task but it is one that we consider should now become the central focus of the Learning in Science Project (Primary).

What are the implications of all the above for our research? In our view future research tasks include;

Topics and concepts: There is a need to consider what topics should form the central core of primary science. In the context of LISP(P) one consideration must be the New Zealand resource units presently available to teachers. This requires data to be gathered on

i) the topics which are close to children in that they accept them as part of their own immediate world and pertain to phenomena about which children can and do ask questions and form meaningful understandings;

ii) topics and phenomena which children perceive as providing them with an opportunity to do things;

iii) topics which teachers find manageable and successful;

iv) children's concepts which may have important implications for the future development of scientifically acceptable ideas and the relationship of these concepts to the topics.

It would appear desirable, even necessary (Gilbert, Osborne and Fensham, 1982) to establish for certain topics, and concept labels, information about children's views, scientists' views and teachers' views. Associated with children's views we need to know what questions children ask and what understandings they seek.

Doing Things: We need to know what things children like doing. We need to establish which activities, or types of activities, give rise to pupils raising questions and seeking understandings, questions and understandings which are manageable in the school setting.

Skills of investigation: In addition to finding out what questions children ask and what sort of understandings they seek, we also need to know how children go about seeking understandings not only in pupil-directed but also in teacher-directed investigations. Are the skills of investigation that children have, appropriate and adequate for them to arrive at the sort of understanding they seek? Are school resources in terms of books and equipment adequate for children to carry out an investigation successfully?

Explanation: We need to know not only what questions children ask, what sort of understandings they seek, and how they go about seeking understandings, but also what sorts of understandings they use, think adequate, and accept as sound. Another part of this, which is related to our earlier discussion on topics and concepts, is to find out what sorts of phenomena they want to understand, or want explained. Other questions relate to the perceptions that children have of the sorts of phenomena that scientists want to understand, how scientists would obtain understanding and what that understanding would be like. A further question relates to the form of explanation that is appropriate for teachers to give children.

Teaching Strategies: We need to know what practical teaching strategies will enable teachers to gain in competence and confidence and, at the same time, will enable them to provide a classroom environment in which pupils can develop more meaningful interaction with the natural, physical, and technological world. If such strategies can be established then the prospect exists for both teachers and pupils to derive satisfaction from the science lessons.

Classroom implementation: Once classroom strategies have been developed, it is necessary to give serious consideration as to how to provide appropriate resources so that teachers can implement the strategies in their own classrooms. The resources needed to help teachers are likely to include:

(a) material to clarify with teachers the important aims of science teaching;

(b) information as to the topics and concepts which it is desirable to focus on and information on both children's ideas and scientists' ideas with respect to these topics and concepts;

(c) information with respect to a particular topic of the things children like doing, the questions children ask in that situation, the explanations they have for these questions, and what children can do to find answers for their questions and to explore their ideas;

(d) information of specific teaching strategies which can be used to focus children's thinking, to help them raise sensible answers and generate good explanations, to guide them in their investigations and to ensure that at the end of the day pupils have maximised the learning opportunities available.

PRELIMINARY INVESTIGATIONS

Before planning the research to be undertaken in the next two years we considered it desirable to undertake a range of preliminary investigations. These investigations are partly discussed in Symington, Osborne, Biddulph and Freyberg (1982). The investigations and preliminary results from this work include;

(a) What topics are children most interested in? Survey investigations, contrasted with contrived classroom work, suggest to us that children's interest in a topic is likely to be more dependent on the particular way the topic is introduced than on the children's perceived view of the general topic.

(b) What questions do children ask in a given situation? Classroom observations suggest to us that children only rarely ask questions about the natural, physical and technological worlds in the course of a normal lesson. However, if they are specifically asked to generate questions with respect to a particular situation they will do so. Furthermore when children ask questions this stimulates other questions from other children. Examples of questions asked by children in the classroom about rocks is given in Appendix A. There are common questions across classrooms and even across countries.

(c) Which of the questions are of greatest interest to children? Given a set of questions the class has generated, the children regard some questions to be of more interest than others. So far our experience suggests that the questions children are interested in are not always the focus of presently available resource units! For example, a resource unit on "Wood" focuses on flexibility and hardness while children appear to be more interested in how the rings were formed, the purpose of bark, and so on (Symington, Osborne, Biddulph and Freyberg, 1982).

(d) What explanations or answers do children generate? Once a class has generated a set of questions, and chosen those questions they find most interesting, we have asked them to suggest answers to the questions (for example see Appendix B). Children are never short of answers! Furthermore their answers give insights into the way they perceive the questions. They also show how pupils provide a range of explanations that are scientifically acceptable as well as many explanations which are not the province of scientific endeavour and interest. Examples of non-scientific type explanations are: "a tree has bark to make it look pretty", "a tree has bark because God made it like that". The recognition that a range of answers may be scientifically acceptable is important as teachers often focus on what they consider to be the one acceptable scientific answer.

(e) What methods do children tend to suggest to check on an answer? Some recent science programmes have focused exclusively on questions which can be investigated by children using hands-on enquiry. Where such questions occur this type of investigation would appear to be particularly desirable. However our experience so far is that children ask many questions which are non-investigable through hands-on enquiry and our view is that children should attempt to find answers to such questions. Children are interested in asking people, whom they consider might know the answer, what they think. Children also suggest that reference books should be consulted. Scientists also tend to use similar strategies to find answers to their problems!

(f) How successful are children in establishing the validity of answers to questions? At present we are exploring this question. We have to accept that children may often be unsuccessful - so are scientists. Pursuing this approach to science teaching may lead to children being able to distinguish between questions which they can or cannot obtain answers to. This, in itself, is a major scientific skill.

(g) How practical are our views on primary science and how acceptable are our views about the importance of focussing on children questions and explanations? Much of our preliminary investigations over these last few months have been undertaken either by classroom teachers or with the classroom teacher and others observing our work. We have been encouraged by teacher comment. In particular we have noted teachers' interest in learning about children's questions and explanations, and their surprise at the sophistication of these. Some teachers have been encouraged through their observations of our work to find out children's ideas on other topics. The focus on the children, with less focus on imparting science knowledge, would appear to find considerable favour with the primary teacher.

WHERE TO FROM HERE?

In this paper we have set out the implications from our earlier research, and from our thinking about primary science, in terms of a set of research tasks. Our recent preliminary investigations of some of these research questions, and teachers' reaction to the work, encourages us to proceed with these tasks. What is clear to us, at present, is that we will use a range of procedures including individual and group interviews, classroom teaching experiments and classroom observational techniques. Moreover, mindful that our most important audience for the research outcomes are practising classroom teachers, we will continue to involve classroom practitioners in the research at all levels.

It is our view that real progress in research comes through sharing current research with fellow researchers, as well as with practising teachers. We hope this paper provides a focus for further discussion and dialogue.

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APPENDIX A: Questions 10-11 year old children ask about rock

Children in four classrooms, three in New Zealand and one in Australia, handled various pieces of rock and were then asked what questions they had about the rock. The following questions were some that were recorded, and have been ordered to show similarities between countries.

	NEW ZEALAND		AUSTRALIA
1.	What are rocks made of?	1.	What are rocks made of?
2.	How do they get their colour?	2.	What gives rock its colour?
3.	Why are they hard?	3.	Are all rocks hard?
4.	How do rocks get their shape?	4.	Are all rocks the same shape?
5.	Why do rocks have holes in them?	5.	Why do some rocks have holes in them?
6.	Why are some rocks different weights than others?	6.	Are all rocks heavy?
7.	Why are rocks sometimes smooth and flat?	7.	Why are some surfaces rough and some smooth?
8.	Is gold a rock?	8.	Has there been any gold found in rocks?
9.	Why is the diamond the most valuable rock?	9.	Are any of these rocks valuable?
10.	Would coral be the same as rock?	10.	Is chalk made out of rock?
11.	Did all rocks develop from volcanoes?	11.	Why do rocks sparkle?
12.	Do rocks from other countries sometimes drift over here?	12.	Why do some rocks look like wood?

APPENDIX B:

CHILDREN'S ANSWERS TO QUESTION: "Why do rocks have different colours?"

Answers that relate to climate

1. because of the climate
2. the climate of the country
3. it might depend on the different climate

Answers that relate to shape

4. because of the shape

Answers that relate to age

5. because of the age of the rock
6. it might change colour because of its age

Answers that relate to temperature

7. because of the temperature
8. the heat, like in some rocks it could be boiling hot so it turns red
9. if the rock is thrown out of a volcano and the volcano is hotter than usual it would get a dark colour; if it was not as hot it would be a bit lighter
10. the heat changes the colours of the rocks
11. because of the temperature it dries at

Answers that relate to composition of rock

12. because of the different minerals
13. they are made up of different particles
14. because of a variety of chemicals in different rocks
15. when the lava comes out of the volcano it has different textures and chemicals

Answers that relate to location

16. because they are found in different places
17. in their environment
18. because they come from different parts of the world
19. it comes from deeper parts of the ground
20. rocks are different because they sit in the earth for so long
21. where the environment is
22. it might just depend on the country

Answers that relate to uses

23. dyed for certain purposes
24. because when they make the road they put colours

Answers that relate to type or number of colours

25. some rocks could have different colours to other rocks
26. rocks could have one or two; they could just have one